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Article

Developmental Trajectories of Verbal and Nonverbal Skills in Individuals With a History of Specific Language Impairment: From Childhood to Adolescence

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Purpose: To investigate the longitudinal trajectories of verbal and nonverbal skills in individuals with a history of specific language impairment (SLI) from childhood to adolescence. This study focuses on SLI only and investigates within-participant measures across abilities.

Method: Verbal and nonverbal skills were assessed in 242 children with a history of SLI at ages 7, 8, 11, 14, 16, and 17. Discrete factor growth modeling was used to examine developmental trajectories for the whole group and to identify subgroups on the basis of a novel, developmental, multidimensional approach.

Results: When expressive language, receptive language, and nonverbal skills were scaled to a common metric, the group of individuals with a history of SLI as a whole had stable skills growth

throughout the 10-year time frame. Seven language subgroups were identified, but these differed only in severity and did not display mutually distinctive patterns of growth development. In contrast, 6 nonverbal skills subgroups were identified, and their trajectories did differ significantly, with evidence of deceleration in around one third of the sample.

Conclusion: Individuals with a history of SLI show steady language growth from age 7. However, different patterns of growth of nonverbal skills are observed from childhood to adolescence.

Key Words: specific language impairment, SLI, developmental trajectories, verbal skills, nonverbal skills, subgroups

Both verbal and nonverbal abilities are implicated in the definition of *specific language impairment* (SLI): the presence of language deficits in the context of adequate nonverbal skills. Although understanding the development of these skills in children with SLI is of both theoretical and clinical importance, it requires the elucidation of developmental trajectories based on longitudinal data (Thomas et al., 2009), and these are

not plentiful in research into SLI. This study investigates the nature of the developmental trajectories of verbal and nonverbal skills in children with SLI.

Previous related work has considered how the development of skills, in particular language skills, in children with SLI differs from the course observed in typically developing (TD) peers. There is some evidence that children with SLI have delayed language, but this can be followed by acceleration in language growth relative to TD peers, at least up until the early school years (Bishop & Edmundson, 1987). Other researchers have put forward the “tracking” hypothesis, which suggests that children with SLI have delayed language skills at the beginning but then develop on a parallel trajectory to TD children (Law, Tomblin, & Zhang, 2008). There are also some suggestions that there may be a plateau in the development of language skills in children with SLI in relation to peers (for a review, see Leonard, 1998). In terms of nonverbal skills, there is evidence that performance declines in relation to peers in individuals with SLI from childhood to early adulthood (Botting, 2005; Tomblin, Freese, &

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Records, 1992). In this investigation, we take a different approach and study the growth of verbal and nonverbal skills within a large sample of individuals with a history of SLI from childhood to adolescence (age 7 to 17 years). We examine the stability in the growth of skills in individuals with a history of SLI in relation to their own peers also with a history of SLI. Thus, growth is evaluated with respect to other individuals and subgroups within the sample.

Development of Language Skills in Individuals With SLI

Some empirical data on the longitudinal development of language skills in individuals with SLI have been reported. The majority of these studies take a comparative view and evaluate the growth of language skills in individuals with SLI with that of their peers via the use of TD comparison groups or the use of normative data available from the instruments used.

Bishop and Edmundson (1987) investigated the development of language skills in children who had language difficulties at age 4. Participants were split into four groups: a control group, a good-outcome SLI subgroup (children who caught up and reached normal language competence at age 5;6 [years;months]), a poor-outcome SLI subgroup, and a poor-outcome general delay subgroup (nonverbal ability scores more than two standard deviations below the control group). They were then followed up over the next 18 months. The findings revealed steady development over the 18-month period for all three subgroups of children with SLI. This study clarified that there may be developmental catch-up of language for some individuals with SLI in early childhood. It also underlined that the rate of language development is likely to be similar to that of TD peers, at least from age 6 onward, even when language abilities are initially more severely impaired or when there has been accelerated growth prior to 5;6 years of age. Accelerated growth in language abilities of children with SLI beyond 6 years of age, to our knowledge, has not been documented.

Similarly, when looking at a variety of tense and agreement measures, Rice, Wexler, and Hershberger (1998) found that 3- to 8-year-olds with SLI were delayed but did not differ in the developmental trajectory of these specific aspects of expressive language. The developmental trajectories for tense marking showed linear and nonlinear (quadratic) components for children both with and without SLI. The data indicated changes in rate of growth across time, with periods of more accelerated growth for both groups. Rice, Redmond, and Hoffman (2006) found that the 5-year growth trajectory of mean

length of utterances (MLU) was primarily linear, demonstrating stable growth. No differences were found in the trajectories of growth when comparing the children with SLI with MLU-matched TD children.

Studies that have focused on vocabulary development, however, have found a developmental decrease in standard score measures of this capacity in individuals with SLI, indicating that these children are falling further and further behind their peers in terms of their vocabulary size from childhood to adolescence (Mawhood, Howlin, & Rutter, 2000; Rice et al., 2006; Stothard, Snowling, Bishop, Chipchase, & Kaplan, 1998). Nonetheless, this finding has not been universally replicated. Beitchman, Wilson, Brownlie, Walter, and Lancee (1996) found stability in vocabulary growth from age 5 to 12 years. The lack of consistency of these findings may be related to a number of factors, including differences in measurements used and the likely presence of different proportions of children with SLI with reading difficulties in different studies (e.g., Snowling, Bishop, & Stothard, 2000; St. Clair, Durkin, Conti-Ramsden, & Pickles, 2010). Reading and print exposure are an important source of new vocabulary from middle childhood to adulthood (Cunningham & Stanovich, 1991).

In one of the most extensive longitudinal studies of SLI, Beitchman et al. (1996) conducted a 7-year follow-up on subgroups of children with different profiles of language difficulties (as well as a comparison group with typical language skills). Subgroups were identified via cluster analysis of a variety of measures and included considerations of the modalities affected (whether expressive and/or receptive skills). Considerations of deficits in different modalities have featured prominently in attempts to characterize the heterogeneity of difficulties in SLI via subgrouping (Conti-Ramsden & Botting, 1999b; Rapin, 1996; Wolfus, Moscovitch, & Kinsbourne, 1980). In the Beitchman et al. (1996) study, the differences in language ability between the subgroups were maintained from age 5 to 12, thus indicating stability in language profiles from early to late childhood. A further follow-up 7 years later, when the individuals were approximately 19 years old, showed continued relative stability in language ability (Johnson et al., 1999). The authors concluded that children's linguistic competencies follow the same developmental pattern no matter what level of language proficiency is reached.

Work on profiles of language growth has also been carried out with the Manchester Language Study cohort (Conti-Ramsden & Botting, 1999a, 1999b; Conti-Ramsden, Crutchley, & Botting, 1997). Law et al. (2008) investigated the developmental trajectories in receptive language skills in this U.K. sample of children with a history of SLI from age 7 to age 11 years. Overall, they found linear growth in receptive language for the group as a whole. This pattern was replicated when children were classified

in language-normal, expressive language-impaired, receptive-expressive language-impaired, and complex SLI subgroups. In this analysis, Law et al. found, once again, stability in the receptive language trajectories with differences in the subgroups relating mainly to severity. There were some differences in the growth trajectories in the subgroups, but these differences accounted only for 4% of the variance between the subgroups.

In summary, the available research literature suggests that in early childhood, individuals with SLI may show different developmental trajectories in different domains of language (Rice et al., 1998, 2006). There is also evidence that for some children with SLI, there may be accelerated growth in language skills, but once again, in general this is most evident in the preschool and early school years (Bishop & Edmundson, 1987). In older children and young people with SLI, there is some evidence of slower rate of growth when the particular domain of vocabulary is examined from childhood to adolescence, although this finding is not universal (Beitchman et al., 1996). However, the available literature also suggests that in older children and young people with SLI, the rate of growth in more global language abilities in the expressive-receptive modalities is likely to be stable.

Studies, however, have been relatively few in number and have usually focused on relatively short periods of development (periods of 2 to 5 years but with some notable exceptions—e.g., Beitchman et al., 1996). Studies with older children, including investigations with the Manchester Language Study cohort, have examined the developmental trajectories of language skills, but the focus has been on a particular modality (e.g., receptive skills; Law et al., 2008) and for relatively short periods in development (e.g., from 7 to 11 years; Law et al., 2008). Few investigations have examined developmental language trajectories taking into consideration language skills in both expressive and receptive modalities.

Development of Nonverbal Skills in Individuals With SLI

Several studies have reported a decline in performance of nonverbal tasks, relative to age expectations, from childhood to early adulthood, in individuals with a history of SLI. Tomblin et al. (1992) in one such study of 35 participants reported a drop of approximately 10 standard scores in performance IQ (PIQ) from childhood to early adulthood (mean age = 21 years). Similar findings were described by Johnson et al. (1999). These investigators found a significant decline in PIQ standard scores from childhood to young adulthood (19 years) in 49 individuals with SLI. This pattern was different from that observed in a TD control group and a speech impairment

group. The participants in this study had a relatively high childhood PIQ. The observed decrease still resulted in adult PIQ standard scores within the normal range.

Mawhood et al. (2000) investigated the difference between childhood and adulthood PIQ standard scores in 19 individuals with primarily receptive language problems. Two measurements were obtained: Raven's Matrices and the Wechsler Intelligence Scale for Children (WISC) or Wechsler Adult Intelligence Scale (WAIS), as appropriate. The participants were between 4 and 9 years of age at the beginning of the study and were followed up in their early to mid-20s. For both measurements, there was a decline in standard scores. For the WISC-WAIS comparison, there was a decrease of approximately 11 points, whereas the Raven's Matrices showed a decline of about 15 points. Nonverbal abilities scores fell from within the normal range in childhood to below the normal range in early adulthood.

Stothard et al. (1998) followed up a sample of 71 participants with a history of SLI at 16 years. Childhood data for these participants had been reported by Bishop and Adams (1990). The sample was split into three groups—resolved, persistent, and general delay—on the basis of their language and nonverbal abilities at age 5. All three groups showed a decline in performance on two subtests of the WISC from age 5 to age 16. What is interesting to note is that the developmental lag was most evident in the persistent SLI and general delay groups.

More recently, Botting (2005) documented a decline in performance of nonverbal tasks from 7 to 14 years in 82 individuals with a history of SLI who formed part of the Manchester Language Study cohort. This decline was substantial: above average nonverbal skills at age 8 (a mean standard score of 109) dropping to within the lower end of the normal range at age 11 (a standard score of 86) and then further at age 14 (a standard score of 83). However, there were methodological challenges with this investigation as the design involved changes in the instruments used to measure nonverbal skills across development. Although Botting acknowledged that the influence of measurement issues could not be ruled out, she argued that the magnitude of the decline was indicative of real change. To help solve this concern, there is a need for further methodological refinements in the investigation of the growth trajectories of nonverbal skills of this cohort of individuals with a history of SLI.

Thus, several different long-term longitudinal studies have found evidence for a decrease in the rate of growth of nonverbal skills in individuals with SLI from childhood to early adulthood. These findings are challenging, particularly as the defining criteria for SLI diagnosis involve having adequate nonverbal abilities for language learning, that is, PIQ within the normal range. Changes in instruments, although warranted in

light of the age ranges investigated and developments in the instruments becoming available in the course of longitudinal research, could introduce measurement confounds that undermine the utility of direct comparisons of standard scores over time (Mawhood et al., 2000; Pearce, 1983; Wilkes & Weigel, 1998). To our knowledge, there are no studies that have used techniques other than the examination of standard scores in investigating the developmental trajectories of nonverbal skills in individuals with a history of SLI. Put simply, we cannot tell whether any reported changes with age are simply due to changes in instrument.

Theoretical Considerations

We briefly consider maturational and neuroconstructivist theories in order to provide a general frame for issues relevant to understanding the development of atypical populations and, in the case of this study, SLI. Although we do not set out to distinguish between these two theoretical approaches directly, we use them to provide a context for the focus of this study, that is, the inclusion of both verbal and nonverbal skills in the investigation of growth trajectories in individuals with a history of SLI, and to situate our findings within the framework of these conceptual models.

Maturational explanations suggest that variations in the rate of brain maturation, controlled by genes, are likely to be responsible for specific delays in the development of particular brain functions. This framework often presupposes that the brain has preformed domain-specific cognitive systems from the beginning of development. In the case of SLI, mechanisms related to language are immature and/or impaired so that we usually observe late language-specific onset followed by relatively invariant trajectories of growth, although these may vary across different domains of language, for example, vocabulary versus grammar (Rice, 2004). Within this framework, the conceptualization of SLI as a disorder entails the juxtaposition of immature and/or impaired language-specific cognitive systems and intact areas of functioning, in particular nonverbal skills. The characteristics of growth trajectories of language therefore do not necessarily affect what happens with the trajectories of nonverbal abilities across developmental time. Although there have been recent advances in our understanding of the neurobiology of SLI, there is still little direct evidence of delayed brain development in this population. Furthermore, few atypicalities have been identified (Webster & Shevell, 2004).

The neuroconstructivist approach provides a different explanatory framework (Karmiloff-Smith, 1998; Thomas & Karmiloff-Smith, 2002). This position accepts

the importance of genetic and neurobiological influences in neurodevelopmental disorders, such as SLI, but suggests that it is unlikely that the brain has domain-specific cognitive systems, such as language, from the beginning of development. Both maturational and neuroconstructivist explanations underline the contribution of genes and the environment. However, neuroconstructivism puts development at the heart of explanations of neurodevelopmental disorders. This approach gives as much of a key role to environment as to genetic influences, emphasizing the crucial importance of interactions in development across time. Explanations of stability in growth of language skills in SLI are likely to involve domain-general mechanisms, relatively subtle initial differences in neurobiology, and continued gene–environment interactions across developmental time. Within this framework, the conceptualization of SLI as a disorder entails interactions across different areas of functioning. One should observe co-occurring difficulties in other areas of functioning, including nonverbal abilities, across developmental time, although the severity of these difficulties relative to the severity of language impairment remains an open empirical question.

The Present Study

In this study, we characterize the developmental trajectories of verbal and nonverbal skills in a large group of individuals with a history of SLI who are part of the Manchester Language Study. We extend the work already undertaken with this cohort by taking a wide developmental window, examining changes from childhood to adolescence over a 10-year span (7 to 17 years). In addition, we undertake a more quantitatively determined approach to subgrouping in SLI than has been undertaken in previous research.

With respect to verbal skills, the aim was to examine both expressive and receptive modalities of language ability simultaneously, at multiple time points, in order to investigate in fine detail potential distinctive patterns in trajectories of language growth. Our approach included first examining the SLI group as a whole to investigate the overall characteristics of the language trajectories. This was followed by a subgroups analysis that investigated, at a fine-grained level, potential differences in patterns of language growth that may have been obscured by the broad, overall group analysis. It also involved investigating what proportion of individuals were “prototypical” of the trajectories identified, in order to ascertain the extent of variability present in our participants. In addition, the design of the study, that is, the examination of both expressive and receptive language, afforded the opportunity to investigate what is the most common relationship

between these two modalities in individuals with SLI and to characterize the developmental trajectory of their relationship. Given the starting point of our observations at 7 years of age and previous research findings, we predicted relatively stable growth trajectories of verbal skills in individuals with SLI and that this would be reflected in both expressive and receptive language modalities as well as in the relationship between them.

With respect to nonverbal skills, the aim was twofold. First, we investigated the developmental trajectory of PIQ, taking the same approach as used in the language trajectory analyses, namely, an initial whole-group characterization, followed by a fine-grained subgroup analysis and then a “prototypical” analysis. On the basis of previous research findings, including work with this cohort, we predicted a slowing of growth of nonverbal skills for the group as a whole. In addition, examining changes at the level of empirically derived subgroups provides evidence as to whether decline is a universal phenomenon among individuals with SLI or whether some are more susceptible. Second, we investigated the relationship between language and PIQ in SLI. The traditional definition of SLI involves a dissociation between verbal and nonverbal skills, with verbal skills being affected in the presence of adequate nonverbal abilities. On the basis of previous research, we predicted developmental changes in the relationship between verbal and nonverbal skills from childhood to adolescence—specifically, that they would not be associated in the early years but may become so in later childhood and adolescence.

This investigation draws on and extends the rationale of Thomas et al. (2009) that examining developmental trajectories can enrich the understanding of different processes between typical and atypical groups: We propose that an equally productive strategy would be to investigate developmental patterns of growth in areas relevant to communication functioning at the level of empirically distinguished subgroups among the atypical (in this case, SLI) sample.

Method

Participants

Longitudinal data from participants 7 to 17 years old from the Manchester Language Study provided an opportunity to examine developmental trajectories of individuals with a history of SLI. The Manchester Language Study was not originally designed for this purpose, and some issues need to be considered in relation to initial criteria for recruitment, age of participants at recruitment, and changes in measurement across time; however, the study does afford a large database with measures collected on individuals with SLI over a lengthy period.

An initial cohort of 242 children (57 girls) with a history of SLI took part in this study. These individuals represented a randomized sample of all 7-year-olds attending 50% or more of their school week in a language unit. *Language units* are classes that offer specialist language environments. The staff usually includes a specialist teacher and a classroom or speech-therapy assistant; regular speech and language therapy input is provided by a qualified therapist.

All known language units across England were contacted by telephone, and teachers were asked to report how many 7-year-old children were attending more than 50% of the school week. They were also asked about additional difficulties; children with known current hearing loss, major physical disabilities, and definite diagnosis of autism or of moderate learning difficulties were excluded at this stage. Thus, no specific “SLI” criteria were used at selection. Rather, enrollment in a language unit and the absence of other diagnoses were used as identification of the sample. However, subsequent analysis showed that 84% of the sample met traditional discrepancy criteria for SLI. Approximately 38% had only expressive difficulties, 53% had difficulties in both expressive and receptive modalities, and 9% were thought by clinicians to have complex or pragmatic language difficulties (Conti-Ramsden & Botting, 1999a). Three children had poor nonverbal IQ (< 70 standard score) but were not thought to be globally delayed, hence the absence of diagnoses of moderate learning difficulties. Thus, the children participating in this study had not been selected a priori on the basis of having met criteria for SLI, and they exhibited a variety of types and severity of language impairments. Full details of the initial cohort’s profiles of impairment can be found in Conti-Ramsden et al. (1997). The children were 7 years of age at recruitment. On the one hand, this age of recruitment has the advantage of identifying individuals with likely persistent language difficulties. On the other hand, by 7 years of age, children have a number of years of language experience that this study cannot characterize.

The children were seen again at ages 8 (230; 54 girls), 11 (200; 51 girls), 14 (109; 30 girls), 16 (44; 15 girls), and 17 (90; 29 girls), the last wave consisting of 37% of the initial cohort. Ethical approval from the University of Manchester was obtained for each testing wave. There was a decrease in the number of participating children at age 14 as a result of funding available at this phase of the study. Because of funding restrictions, the data available at 16 years are few because psychometric tests were conducted only if there were no psychometric data collected at age 14. Thus, the individuals involved at the 14- and 16-year phases were independent of each other. However, there was no systematic reason why participants were tested at 14 or 16, so data at these ages are simply random

subsets of the entire sample of 242 individuals. The number of children used in each analysis varied slightly as a result of missing data in the expressive, receptive, or non-verbal measures.

There were no significant differences between boys and girls on either receptive or expressive language ($ps > .3$). There was a significant gender difference in terms of PIQ ($\beta = -.46$, $CI = -.72$ to $-.20$, $p < .001$). Boys had higher PIQ than did girls ($M = 98.95$, $SD = 20.56$; and $M = 90.37$, $SD = 20.78$, respectively), but the means for each group were within the normal range. Parental income and maternal education information were collected at age 16 via a parental questionnaire. Parental income was divided into four bands (under £10,400 per annum; £10,401–£20,800; £20,801–£36,400; or more than £36,401). There was no difference in either receptive or expressive language depending on income level ($p > .1$ and $p > .06$, respectively) nor in PIQ ($p > .1$). Maternal education was coded as no educational qualification, General Certificate of Secondary Education to some college education, or university or postgraduate degree; similarly, there was no difference in receptive or expressive language depending on maternal educational status ($p > .2$ and $p > .10$, respectively) nor in PIQ ($p > .3$).

Measures

Verbal ability measures. Receptive language and expressive language were measured at each time point. For receptive language, the Test for Reception of Grammar (TROG; Bishop, 1982) was used at ages 7, 8, and 11. At age 14, the Receptive Language Composite (RLC; Oral Directions, Word Classes, Semantic Relationships) from the Clinical Evaluation of Language Fundamentals, Third Edition (CELF-3; Semel, Wiig, & Secord, 1995) was administered, whereas at age 16, the Word Classes subtest of the Clinical Evaluation of Language Fundamentals—Revised (CELF-R; Semel, Wiig, & Secord, 1987) was the only receptive measure available for this age group. Finally, at age 17, the Receptive Language Index (RLI; Word Classes Receptive, Understanding Spoken Paragraphs, Semantic Relationships) of the Clinical Evaluation of Language Fundamentals, Fourth Edition (CELF-4; Semel, Wiig, & Secord, 2003) was used.

For the expressive language measure, the information score of the Bus Story (Renfrew, 1991) was used at ages 7 and 8. At ages 11 and 16, the expressive measure was the Recalling Sentences subtest of the CELF-R. At age 14, the Expressive Language Composite (ELC; Formulating Sentences, Recalling Sentences, and Sentence Assembly) from the CELF-3 was administered; and at age 17, the expressive measure was the Expressive Language Index (ELI; Word Classes Expressive, Formulating Sentences, Recalling Sentences) from the CELF-4.

A number of considerations dictated the choice of instruments used. Increases in age and availability of normative data (e.g., use of CELF-4 for availability of normative data at 17 years, which previous versions of the CELF did not have) as well as changes in testing constraints were particularly relevant in this study (e.g., CELF-3 at age 14 years, where testing time allowed for a number of subtests to be administered for each modality examined, whereas at age 16 years, there were constraints that meant that single subtests needed to be used). This resulted in a less than ideal situation of having different measures or versions of measures at different time points. We acknowledge this as a notable limitation of our study, and accordingly we attempted to minimize its potential effects with the modeling approach we used in the analysis.

Nonetheless, the issue still remains as to the nature of the underlying construct that each of the language tests tapped. For expressive language, for example, tests included a narrative, a single-sentence repetition measure, and a composite measure. We want to emphasize that part of our purpose was to tap a common core expressive or receptive language ability—in other words, “L”—across age. To this end, we chose tests that required processing that went beyond single word knowledge and involved expressing or understanding linguistic relationships. Whenever there were constraints to use single subtests (at 16 years), we aimed to use the most informative subtest available. For 16 years, therefore, the CELF-R was used, because the specific subtests chosen had previously been shown in the literature to be good indicators of overall language skills in the modalities examined (Conti-Ramsden, Botting, & Faragher, 2001; Gillon & Dodd, 2005; Stothard et al., 1998). This approach, we would argue, is more justifiable when investigating development in children who are older, which is the case in this study. The evidence reviewed in the introduction suggests that developmental trajectory differences in different domains of language functioning are more likely to be observed in younger children.

Nonverbal ability measures. For measurement of nonverbal skills, PIQ was used. Increases in age and availability of normative data were the most important considerations for choice of instruments. Raven's Coloured Progressive Matrices (RCPM; Raven, 1986) were administered at ages 7 and 8. This test consisted of colored patterns with a piece missing; the task was to pick the correct missing piece from six options. This instrument has norms for children ages 5 to 11 years. At ages 11, 14, and 16, the U.K. version of the Wechsler Intelligence Scale for Children—Third Edition was used (WISC-III UK; Wechsler, 1992). The subtests used at age 11 were Block Design and Picture Completion. In addition, at ages 14 and 16, the following subtests were added: Codes, Picture Arrangement, and Object Assembly.

The PIQ composite was calculated at each time point. At age 17, the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) was used (subtests were Block Design and Matrices), as the norms for the WISC–III UK extended only to age 16. PIQ composite was obtained from the WASI, but it must be noted that U.S. norms were the only norms available for this measure.

Thus, we also had different measures for different time points in the nonverbal domain. Once again, we attempted to minimize potential effects of differing psychometric properties with the modeling approach we used in the analysis. In addition, the tests used, although different, were all selected because they were well established and widely used instruments designed to tap the underlying construct of nonverbal abilities—in other words, nonverbal “G.” See Table 1 for a summary of the receptive, expressive, and PIQ tests used across the 10-year time frame.

For comparison purposes, the TROG, Bus Story, and RCPM raw scores for each participant were converted to percentile rankings, on the basis of published norms; each percentile ranking was then converted to a standard score (with a mean of 100 and standard deviation of 15). The CELF–R and CELF–4 receptive and expressive composites and indexes used at age 14 and 17 are inherently in a standard score format.

Adjusting for differing psychometric properties across tests. The standardization of many cognitive measures is often poor in the tails of the distribution, with standard scores often displaying substantial floor effects not evident in the raw scores (see Thomas et al., 2009, on

the importance of avoiding floor and ceiling effects in charting developmental trajectories). This problem is most clearly shown in the analysis of the Bus Story scores at age 7, as there was a substantial floor effect in the standard scores of this test. That is, 49% of children scored around the standard score of 75. However, the raw scores associated with this standard score varied from 3 to 26. It is likely that there are substantial differences reflected between a raw score of 3 and a raw score of 26. Yet, because both these scores represent extremely low scores relative to the distribution of scores in a TD population, they are both represented by the 5th percentile, which translates to a standard score of around 75. Figure 1 further illustrates the problems in using standard scores from different tests that measure verbal and nonverbal skills to examine developmental trajectories. The standard score data show consistent levels of abilities over time when the same measure is used but not across measures. This is observed for expressive and receptive language as well as for PIQ, albeit the latter being more pronounced. Note, for example, a change for expressive language at 11 years when there is a change of instrument from the Bus Story to the CELF, for receptive language at 14 years when there is a change of instrument from TROG to the CELF, or for PIQ at 11 years when there is a change of instrument from RCPM to the WISC. Thus, from these standard score data, one cannot tell whether the changes observed are real variations in development within the group of individuals with SLI or the result of calibration error related to the different tests used across time.

Given that the focus of our study was on SLI only (participant measures across level of ability) and not on growth relative to typical peers, we adopted a specific method to avoid potential artifactual change arising from differences in the tests used, fitting multivariate growth curve models to the raw scores. To obtain equivalent raw score data for the CELF and PIQ composites, the raw scores of the respective individual subtests were summed. From the model estimates and raw score data, we derived a within-sample score referred to as a “scaled score.” This is described more fully in the next section.

Analysis

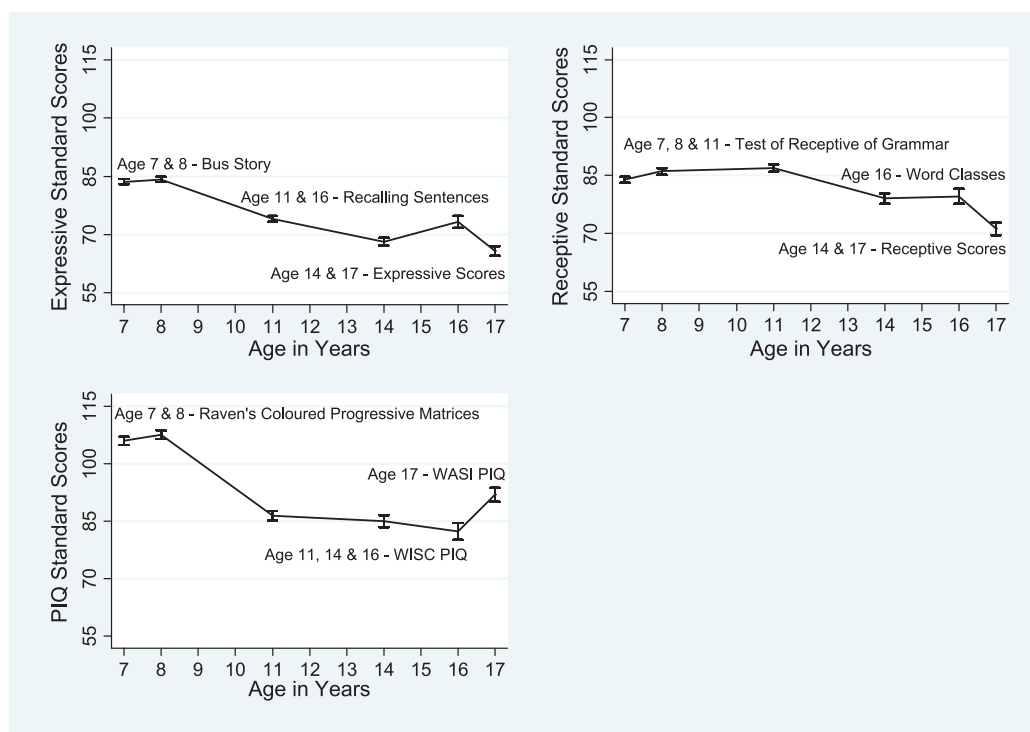
All analyses were done with the Stata/SE statistical program (StataCorp, 2007). Because of the previously mentioned drawback of standard scores masking the real variability found within the raw scores at the lower end of the distribution, we examined the relative growth trajectories. We did this by creating a scaled score from the raw score data and estimated model parameters from a factor growth curve–trajectory model. This method is similar to that used by Ferrer, Shaywitz,

Table 1. Receptive language, expressive language, and nonverbal skills measures for each time point.

Measure	Age					
	7	8	11	14	16	17
Receptive language	TROG	TROG	TROG	CELF–3 RLC	CELF–R WC	CELF–4 RLI
Expressive language	Bus Story	Bus Story	CELF–R RS	CELF–3 ELC	CELF–R RS	CELF–4 ELI
Nonverbal skills	RCPM	RCPM	WISC–III	WISC–III	WISC–III	WASI

Note. TROG = Test for Reception of Grammar; CELF–3 = Clinical Evaluation of Language Fundamentals, Third Edition; RLC = Receptive Language Composite; CELF–R = Clinical Evaluation of Language Fundamentals—Revised; WC = Word Classes subtest; CELF–4 = Clinical Evaluation of Language Fundamentals, Fourth Edition; RLI = Receptive Language Index; RS = Recalling Sentences subtest; ELC = Expressive Language Composite; ELI = Expressive Language Index; RCPM = Raven’s Coloured Progressive Matrices; WISC–III = Wechsler Intelligence Scale for Children—Third Edition; WASI = Wechsler Abbreviated Scale of Intelligence.

Figure 1. Expressive language, receptive language, and performance IQ (PIQ) ability (in standard score format) from age 7 to 17 (whole sample means with standard error bars).



Holahan, Marchione, and Shaywitz (2010), which used a longitudinal design to derive z scores from the raw score of reading ability. However, our case was more complicated in that we also needed to account for changes in tests used. We fitted models to examine differing trajectories in language ability (using both receptive and expressive language simultaneously), and we also fitted models to examine differences in the trajectories of non-verbal ability (as measured by PIQ).

Factor growth curve models were fitted using the “glamm” procedure (generalized linear latent and mixed models; www.gllamm.org; Rabe-Hesketh, Skrondal, & Pickles, 2004) command within the Stata/SE (StataCorp, 2007) statistical program. The language models allowed language ability to vary on the basis of the intercept (which relates to overall language ability level only, that is, level of severity), linear trends (allowing differences in linear trajectory), and quadratic trends (allowing differences in curvilinear trajectory) for each language modality (expressive and receptive). The PIQ models were also allowed to vary in the same manner as the language models, that is, variation in the intercept (which relates to overall nonverbal skills level only) as well as linear trends and quadratic trends for nonverbal skills. In addition, models with unstructured patterns were fitted in which age was treated categorically as a set of dummy variables

for measurement occasions. For each different language measure (TROG, Bus Story, CELF Recalling Sentences, CELF Word Classes, CELF expressive and receptive composites), parameters were estimated to account for the differences in the means, scales of measurement (factor loadings), and error variances of the raw scores from the different types of measure. The scaled scores were derived from the final, best-fitting, multivariate-factor, growth-curve model. To obtain the scaled scores for PIQ, we applied the same procedure for each different PIQ measure (RCPM, WISC-III, WASI) and the final, best-fitting factor, growth-curve model.

To create these scaled scores, we standardized the raw scores with reference to the initial measure at age 7 (TROG, Bus Story, or RCPM). For the language scaled scores, the predicted mean for each age period was obtained and then subtracted from the individual raw scores to obtain a distribution with a mean of 0 for all scores across all ages. The resulting value was divided by the estimated standard deviation, which was calculated as the square root of the sum of the age- and test-specific variance and the error variance; these values were obtained from the model estimates. The scores were mean centered across all age points (not at each age). This allowed for trajectories to vary (to accelerate or slow down or remain stable across development). This

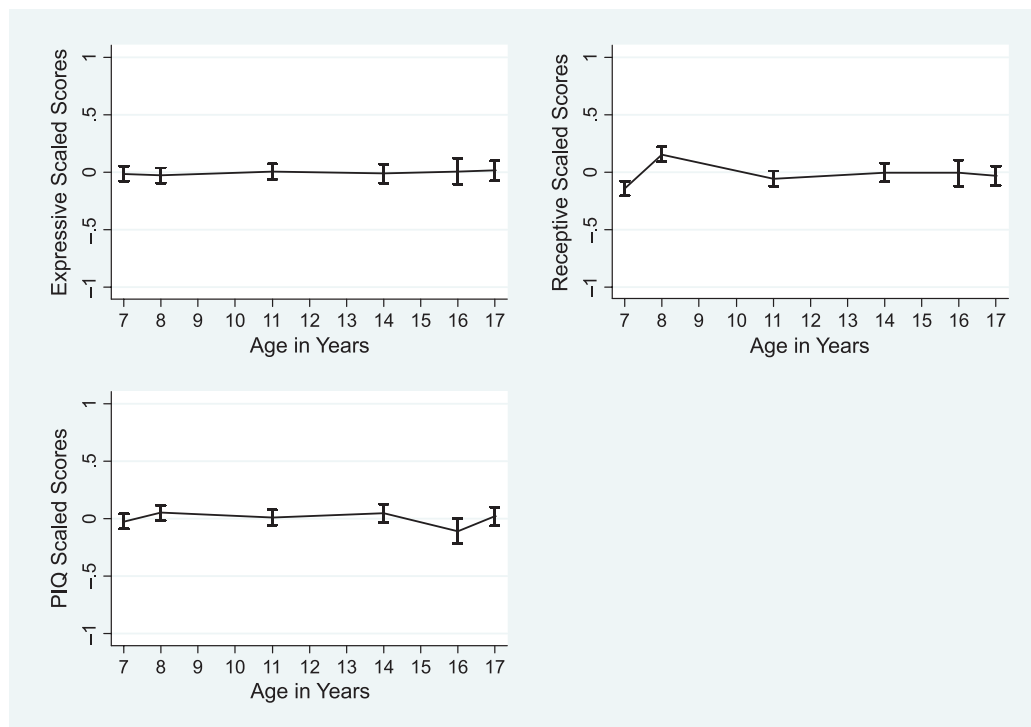
created scores with a variance of 1 and mean of 0 across all age periods. Thus, all expressive and receptive scores at each time point, whether the original measure was the TROG, CELF subtest, or CELF composite, are directly comparable and portray the full range of variation in language ability as evidenced in the raw scores.

Similarly, the PIQ scaled score was obtained by subtracting the raw score from the predicted means, obtaining a distribution with a mean of 0 across all ages. This value was then divided by the square root of the estimated age-specific variances relating to both intercept and linear developmental differences as well as the error variances. In this way, as with the language scaled score, we have a scaled score with a variance of 1 and a mean of 0 across all age periods. The different measurements, therefore, were directly comparable and again portrayed the full range of variation as evidenced in the raw scores.

The scaled score data displayed in Figure 2 are fitted values from the analyses described above. Fitted values were used in place of raw data, as the fitted values accounted for scale differences and for participant attrition. The advantage of these new scaled measures is that they can be used to describe relative change within the sample; a limitation is that they cannot be used as the basis of describing absolute change.

We were also interested in carrying out a more fine-grained level of analysis to examine whether there were any potential differences in the growth trajectories in subgroups of individuals that may have not been evident when the sample was analyzed as a whole. In growth trajectory models, the study participants are assumed to fall into a finite number of subgroups, each with a distinct path of development. The models are run with an increasing number of subgroups until the model fit ceases to improve. For the language data, a series of latent-class growth-trajectory models were run that allowed for 2, 3, 4, 5, 6, 7, and 8 subgroups of individuals with a history of SLI with differing language trajectories. For the PIQ data, the latent-class growth-trajectory models allowed 2, 3, 4, 5, 6, and 7 subgroups of individuals with a history of SLI with differing PIQ trajectories. The Akaike information criterion (AIC) and the Bayesian information criterion (BIC) were calculated to assess how well each model fitted the data, and modeling for additional numbers of subgroups was discontinued when model fit decreased. The most parsimonious model is the one with lowest AIC and BIC. The chosen model was then used to calculate for each participant the empirical Bayes estimates for the posterior probability of belonging to each subgroup, and each participant was assigned to the subgroup with the highest posterior probability. In this way, the probability of how well

Figure 2. Expressive language, receptive language, and PIQ ability (in scaled score format) from age 7 to 17 (whole sample means with standard error bars).



each individual “fits” within each of the subgroups was calculated.

The longitudinal trajectory analyses for the sample as a whole were conducted using maximum likelihood. These analyses allowed us to account for the nonindependent nature of the repeated measures and also for selective attrition on the assumption that the missing data are missing at random (Rubin, 1976). This assumption is often understood incorrectly as “missing completely at random.” In fact, it accounts for selection effects associated with any measured variable in the analyses. Thus, the analyses account for systematic attrition of individuals with a particular past trajectory (e.g., downward). In addition, they take account of systematic differences in data availability at different time points that, as explained earlier, were due to exogenously determined design choices that were driven mainly by funding constraints. The significance and 95% confidence intervals of trends and age contrasts were estimated using standard errors from the estimated parameter covariance matrix. Because of the multiple comparisons within the analyses, the alpha level for the analyses was set at .01. Any significance values between .01 and .05 were treated as marginal.

Results

Developmental Trajectories for the SLI Sample as a Whole

As discussed in the *Analysis* section, to remove the confounding effects of test measurement, we used the scaled scores. Scaled scores had a mean of 0 and a standard deviation of 1. Figure 2 presents a graphic illustration of the scaled scores for expressive language, receptive language, and PIQ over the 10-year time frame. The coefficients reported below reflect the linear increase or decrease in verbal or nonverbal scaled scores over the entire 10-year time period. If significant, these are followed by coefficients that reflect the linear increase or decrease between two specific time points, with a starting point of age 7.

With respect to expressive language abilities, the scaled score coefficients indicate that children with a history of SLI maintain their relative level of attainment from age 7 to age 17, as there were no significant linear, quadratic, or cubic age trends ($ps > .8$). That is, for the whole group, growth was stable, with little evidence of slowing or acceleration in growth of expressive language skills.

With respect to receptive language, the group results were similar, except for the data suggesting accelerated growth from 7 to 8 years. There were significant linear, quadratic, and cubic age trends: $\beta = 1.07$, $CI = .30$ to 1.8 , $p < .01$, for the linear effect; $\beta = -.09$, $CI = -.16$ to $-.03$, $p < .01$, for the quadratic effect; and $\beta = .003$,

$CI = .0007$ to $.004$, $p < .01$, for the cubic effect. When tested categorically, there was a statistically significant growth of receptive language from age 7 to 8, $\beta = .30$, $CI = .19$ to $.41$, $p < .001$. This increase at 8 years was also significantly higher than what was observed at ages 11 and 17, $\beta = .24$, $CI = .12$ to $.35$, $p < .001$, and $\beta = .21$, $CI = .05$ to $.37$, $p < .001$, respectively, and marginally significantly higher than at age 14, $\beta = .18$, $CI = .03$ to $.33$, $p = .02$. There was no difference between ages 8 and 16 ($p = .09$). Thus, the only evidence of significantly greater gains was at 8 years, but this accelerated growth was not maintained by age 11. Ages 7, 11, 14, 16, and 17 did not differ from each other ($ps > .1$).

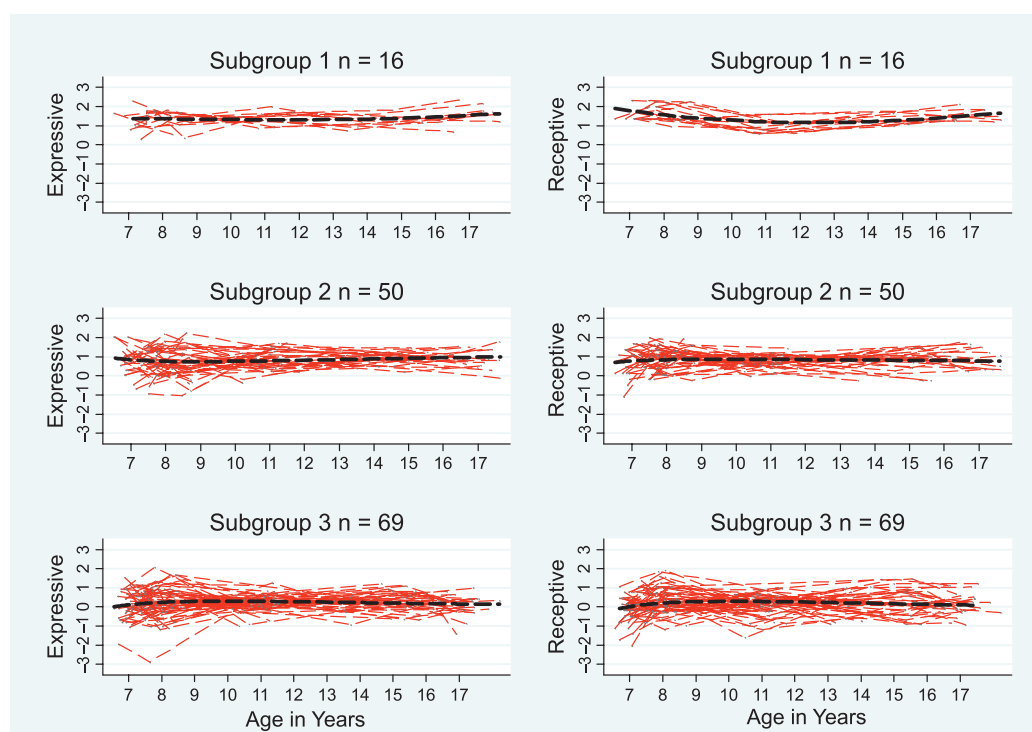
With respect to PIQ, results indicate that the group as a whole maintained the overall rate of growth in PIQ ability from age 7 to 17. There were no linear, quadratic, or cubic trends across development ($ps > .3$), as well as no differences between the different time points ($ps > .1$). Thus, as with expressive language, there is little evidence of slowing or acceleration in growth of nonverbal skills in the group as a whole.

Developmental Trajectory Subgroups: Language Ability

We used structural equation models to search for unique subgroups whose developmental trajectories differed. Recall that the models allowed both expressive and receptive language to vary across time on the basis of intercept differences (indicating equivalent growth across time but at differing language ability levels), linear differences (indicating differences in linear trends between the groups), and quadratic differences (indicating differences in curvilinear trends between the groups). Our approach involved investigating trajectories of subgroups that were identified through both expressive and receptive language across time.

The series of latent-class growth-trajectory models were run that allowed for 2, 3, 4, 5, 6, 7, and 8 subgroups with differing trajectories. The most parsimonious latent-class growth-function model characterizing the differences in developmental trajectory had seven different subgroups, which differed only on the intercept, that is, in the level of severity of their language difficulties. The addition of terms for linear and quadratic variation did not improve the relative fit of the models. Thus, each subgroup differed on the level of language ability only, not on the growth patterns of developmental change. Figures 3 and 4 present the developmental trajectories of expressive and receptive language for each of the seven subgroups (Subgroups 1 to 3 in Figure 3 and Subgroups 4 to 7 in Figure 4). The distribution of the 242 individuals in the sample was as follows: 6.6% in Subgroup 1, 20.7% in Subgroup 2, 28.5% in Subgroup 3, 20.7% in Subgroup 4,

Figure 3. Individual developmental trajectories and average developmental trajectories for both expressive and receptive language in Subgroups 1 to 3.



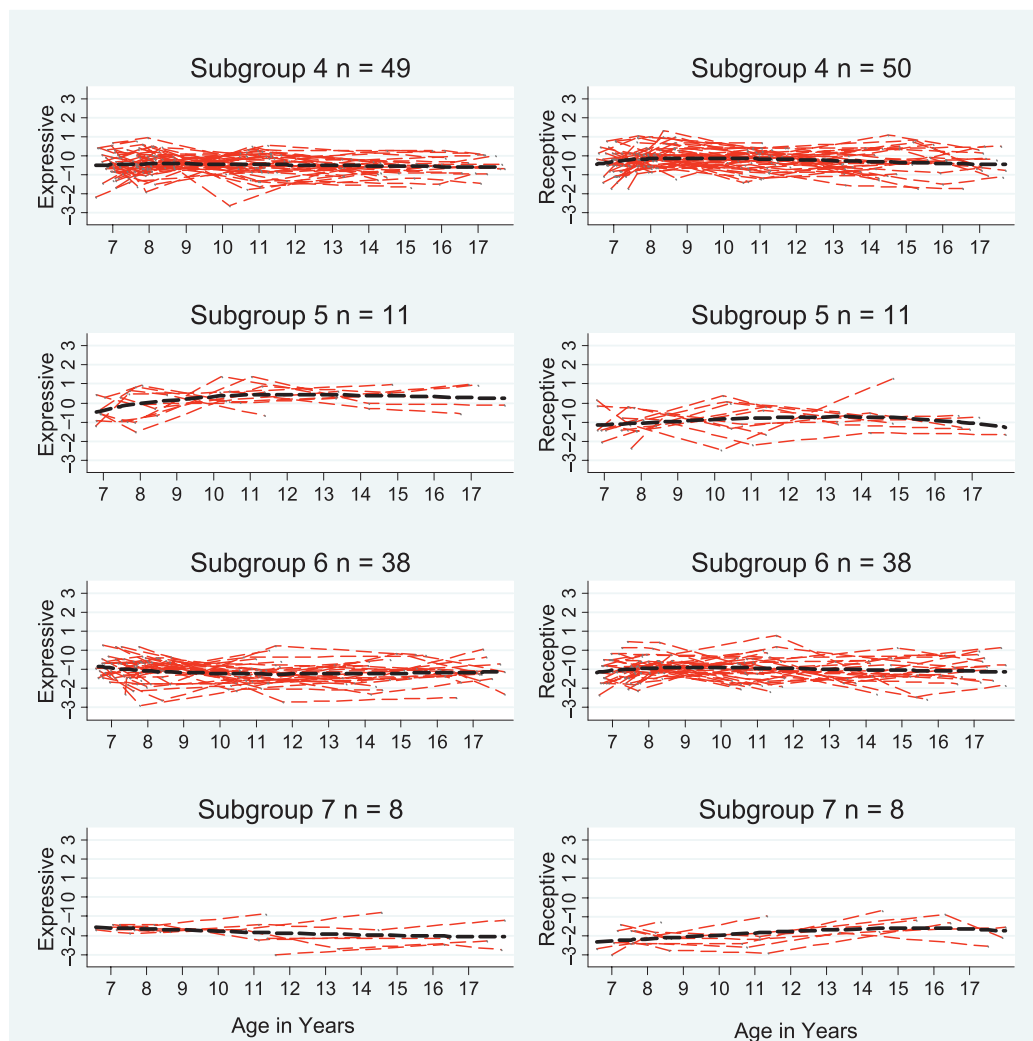
4.5% in Subgroup 5, 15.7% in Subgroup 6, and 3.3% in Subgroup 7. The subgroups are ordered in terms of receptive language ability, such that Subgroup 1 has the highest receptive language ability and Subgroup 7 the lowest receptive language ability. In general, all subgroups had stable growth in expressive and receptive language abilities over the 10-year time period, with little evidence of slowing or acceleration in growth. In other words, those subgroups that had the highest language ability at age 7 still had the highest language ability at 17 years, and the same held for all the other subgroups. Thus, the findings of stable, steady growth of the SLI sample as a whole were replicated at the subgroup level.¹ Recall, however,

¹We conducted two control subgrouping models to test the robustness of the findings. We focused the analyses on partial sets of data that did not have sampling and attrition difficulties characteristic of the entire database. The first control model investigated only the first three time points (ages 7, 8, and 11). This model found four subgroups of individuals that differed only on their level of language ability—that is, intercept-only differences were found. The finding of fewer subgroups when using a restricted number of time points and more subgroups with more time points is what is expected with non-parametric maximum likelihood estimators (Lindsay, Clogg, & Grego, 1991). The second control analysis included only the 90 individuals who participated at age 17 and examined their trajectory from 7 to 17 years. This analysis replicated the main analysis, finding seven subgroups of individuals who differed only on their level of language ability, that is, intercept differences. The addition of any slope differences did not improve either control model, replicating the findings of the main analyses. Thus, both of these additional analyses provided further empirical support for our findings of remarkable stability of the development of language in individuals with SLI from childhood to adolescence.

that each individual was assigned a probability of subgroup membership for each of the subgroups. Across all subgroups, the probabilities would sum to 1 for each individual. The subgroup to which the individual was assigned was simply the subgroup with the highest probability. It is therefore possible that the fit of a number of individuals may be relatively low, in that the probabilities may have been spread broadly over several subgroups. The graphs in Figures 3 and 4 illustrate some individual variation. To investigate this further, we divided individuals whose highest probability of subgroup membership was .75 or over from individuals whose highest subgroup probabilities were under .75. The analysis included only individuals who had three or more data points. Those in the >.75 group were termed “prototypical.” The percentages of prototypical and less prototypical individuals per subgroup and for the whole sample are presented in Table 2. Overall, 76% of individuals were prototypical subgroup members.

We were also interested in examining the relationship between the expressive and receptive language skills in the seven subgroups. Recall that the scaled scores describe relative level of ability within the sample and not absolute levels of functioning. To provide an indication of absolute levels, alongside the scaled scores we present the familiar standard score data to aid the reader’s interpretation of the findings. The scaled scores

Figure 4. Individual developmental trajectories and average developmental trajectories for both expressive and receptive language in Subgroups 4 to 7.



and the average standard scores (across all time points) for expressive and receptive language ability per subgroup are given in Table 3. For Subgroups 1, 2, 3, 4, and 6, on the basis of standard scores, receptive language was significantly higher than expressive language ($ps < .001$). However, the opposite pattern obtained in Subgroups 5 and 7, where expressive language was higher than receptive language: $\beta = -5.63$, $CI = -8.86$ to -2.41 , $p < .005$, for Subgroup 5, and $\beta = -3.56$, $CI = -5.45$ to -1.67 , $p < .005$, for Subgroup 7. Only Subgroup 5 had this unusual pattern evidenced with respect to both scaled and standard scores. This can be seen in Table 3, which shows the means and standard deviations for receptive language and expressive language for each of the subgroups.

Additionally, Figure 5 displays the discrepancy trajectories over time, underlining the main results of the

study with regard to stability of development. The majority of discrepancy trajectories are relatively flat, including that of Subgroup 5, which had the unusual pattern of expressive language being better than receptive language across the developmental period examined. The greatest variation across development was observed in Subgroup 7 (see Figure 4), where receptive scores increased relative to expressive scores across time.

Developmental Trajectory Subgroups: Nonverbal Abilities as Measured by PIQ

As with language ability, a series of latent-class growth-trajectory models were conducted to investigate the possibility of differing trajectories in nonverbal ability over the 10-year time frame. Nonverbal ability was allowed to vary across time on the basis of intercept, linear,

Table 2. Percentage and number of prototypical and less prototypical individuals in each language subgroup and across the entire sample.

Subgroup	Prototypical individuals	Less prototypical individuals
1	85% (11)	15% (2)
2	74% (29)	26% (10)
3	78% (46)	22% (13)
4	64% (28)	36% (16)
5	80% (8)	20% (2)
6	84% (26)	16% (5)
7	100% (7)	0% (0)
Overall	76% (155)	24% (48)

and quadratic differences, similar to the models with language ability. These models allowed 2, 3, 4, 5, 6, and 7 subgroups of individuals with a history of SLI with differing trajectories.

The most parsimonious model had six subgroups that could be distinguished on the basis of both intercept and linear differences, that is, differences in both the level of nonverbal ability and in the patterns of developmental change. The distribution of the 242 individuals in the sample was as follows: 13.2% in Subgroup 1, 25.2% in Subgroup 2, 23.1% in Subgroup 3, 10.6% in Subgroup 4, 6.6% in Subgroup 5, and 21.1% in Subgroup 6. The subgroups have been ordered in terms of mean PIQ across all ages, with Subgroup 1 having the highest ability and Subgroup 6 the lowest ability. As can be seen in Figure 6, Subgroups 1 to 3 had a relatively stable growth in nonverbal abilities over the 10-year time period. Subgroups 4 and 6, in contrast, had a slowing down of growth, that is, deceleration in nonverbal abilities from childhood to adolescence, with more stable growth in later adolescence. Subgroup 5 is small and exhibited accelerated growth of nonverbal abilities from age 7 to around age 14, with more stable growth from 14 to 17 years. Thus, there appear to be differences among individuals with a history of SLI in the developmental trajectories of their nonverbal skills. What is interesting is that differences in patterns of growth of nonverbal skills,

particularly slowing down, appear to be associated with lower-than-average nonverbal abilities at 7 years (i.e., the average refers to the average for the SLI group as a whole, which in the graphs is represented by zero). In contrast, stable trajectories of nonverbal skills seem to be associated with average or above average (once again in relation to the SLI group as a whole) nonverbal abilities at 7 years.

We next investigated the individual variation in PIQ over time in the same manner as we did with the language subgroups. Overall, a substantial majority of the individuals were considered prototypical (74%).

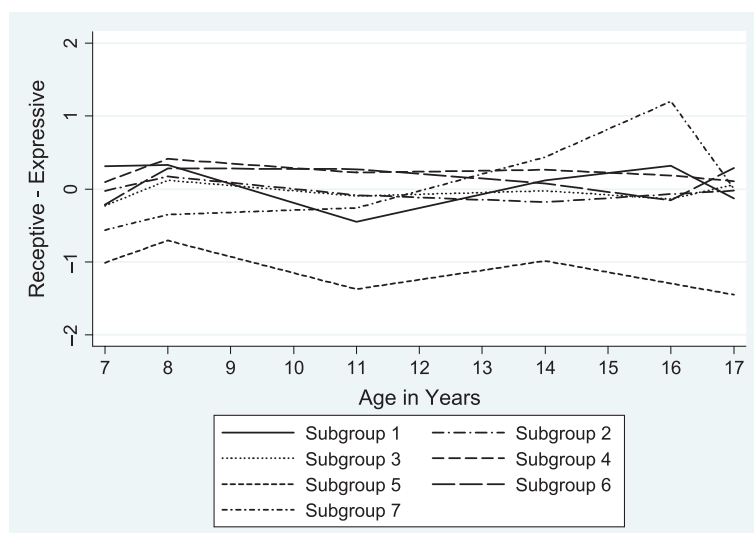
Relationships Between Language and PIQ Subgroups

Table 4 shows the correspondence between the language and PIQ subgroups of individuals with a history of SLI in this study. As can be seen, subgroups characterized by higher language abilities were associated with higher nonverbal abilities, $\chi^2(30) = 478.29$, $p < .001$, Cramér's $V = .26$. To examine this further, we conducted an overall test of whether the level of PIQ differed significantly across the language subgroups (centered at age 11). The pairwise comparisons took into account linear differences as well as the nonindependence of the longitudinal data and attrition. Findings revealed that Subgroup 1 had significantly higher PIQ scores than the remaining language subgroups ($ps < .005$). Subgroup 2 had marginally higher PIQ ability than Subgroup 3, $\beta = -.34$, $CI = -.61$ to $-.07$, $p = .02$; and was significantly higher than Subgroups 4 to 7 ($ps < .001$). Subgroup 3 had a significantly higher PIQ ability than Subgroups 4 to 7 ($ps < .01$). Thus, nonverbal skills appear to covary with language ability, such that the highest language subgroup (Subgroup 1) had the highest PIQ score, followed by Subgroups 2 and 3, respectively. In contrast, nonverbal skills do not appear to covary with language ability in the same way in the subgroups with lower receptive language ability. Subgroup 4 was marginally higher than Subgroup 5, $\beta = -.50$, $CI = -.63$ to $-.01$,

Table 3. Means (SD) for expressive and receptive language in scaled and standard scores.

Subgroup	Scaled		Standard	
	Receptive	Expressive	Receptive	Expressive
1	1.46 (0.44)	1.39 (0.41)	106.92 (11.33)	97.38 (9.50)
2	0.82 (0.54)	0.83 (0.62)	94.68 (10.53)	87.50 (12.08)
3	0.16 (0.65)	0.21 (0.63)	83.69 (11.09)	77.14 (11.12)
4	-0.25 (0.63)	-0.48 (0.59)	78.65 (9.91)	70.72 (9.18)
5	-0.96 (0.74)	0.11 (0.71)	70.30 (12.14)	75.93 (9.93)
6	-1.00 (0.63)	-1.11 (0.63)	70.88 (9.67)	67.99 (9.56)
7	-1.96 (0.59)	-1.81 (0.52)	62.01 (7.16)	65.57 (10.73)

Figure 5. Average discrepancy between receptive scaled scores and expressive scaled scores for each subgroup.



$p = .04$; but did not differ from the remainder of the subgroups ($ps > .05$). Language Subgroups 5, 6, and 7 did not differ from each other ($p > .4$).

Discussion

The present study investigated the growth trajectories of verbal and nonverbal abilities from childhood to adolescence in a large sample of individuals with a history of SLI. The methodological approach involved taking the whole group of atypical language learners as a reference point. Thus, we examined similarities and differences in level of functioning and patterns of growth exhibited within SLI. Both stability and change in individuals' profiles of abilities were observed. On the one hand, although there were differences in the level of language functioning of individuals in the sample, we found stability of growth in verbal abilities, in particular for expressive language. On the other hand, differences among subgroups were found in the patterns of growth of nonverbal skills. Results revealed differences in the level of nonverbal functioning of individuals with a history of SLI and, of importance, developmental changes in the growth of nonverbal skills in a notable proportion of individuals from childhood to adolescence.

Growth of Verbal Skills in SLI

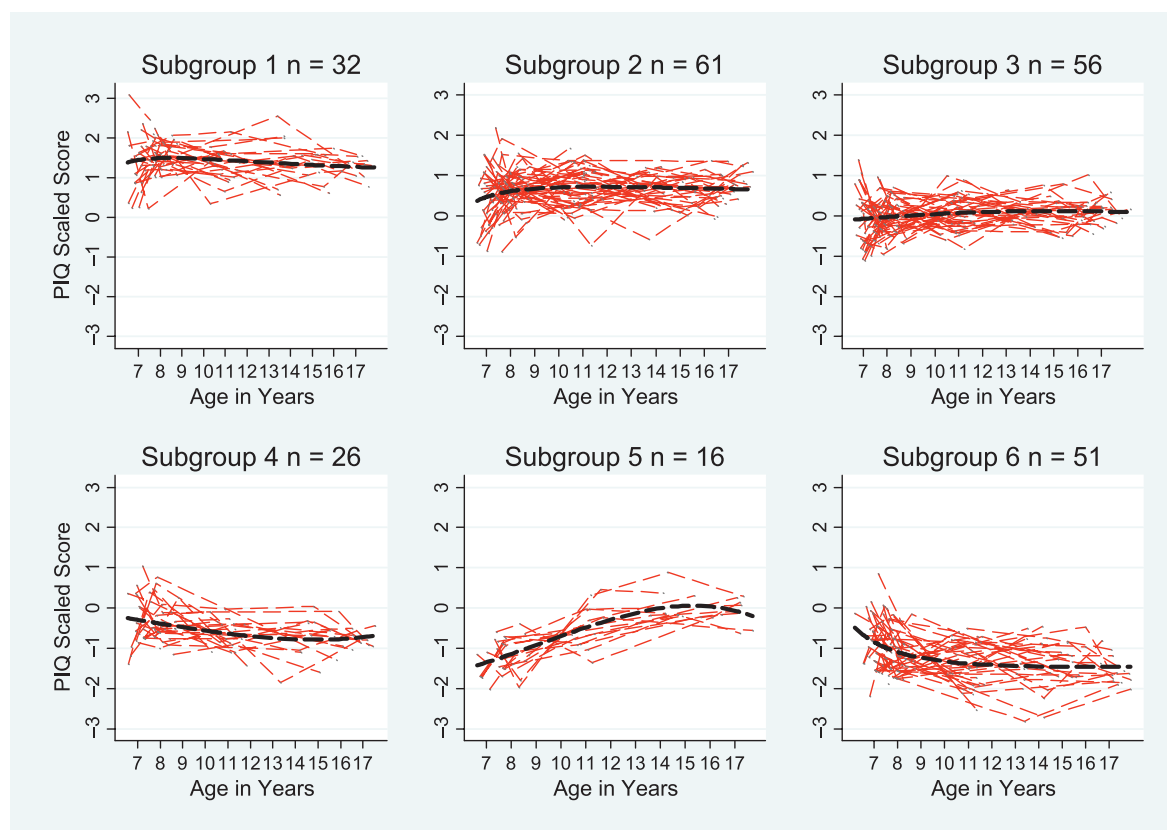
We found overall stable patterns of growth in our sample of individuals with a history of SLI. This was clearly the case for expressive language development. There was evidence for receptive skills displaying more

variability in that receptive language developed at an accelerated rate from 7 to 8 years of age. This accelerated developmental trajectory was not maintained after 8 years. Apart from this, the pattern across development appeared consistent.

The observed accelerated rate of receptive language development may have been due to a number of factors. Here we consider two. First, at 8 years of age, two thirds of the participants were still attending language units. These are intensive language classes with substantial support for language learning (Conti-Ramsden & Botting, 2000). In contrast, by age 11, less than 10% of individuals were receiving such a degree of language-specific intervention in a language unit or language school. Intensive language input may have impacted positively on the trajectories of receptive language growth of children in this study from 7 to 8 years. Second, 7 to 8 years of age was one of the shorter measurement intervals in the study; the other was the interval between 16 and 17 years. Although 1 year is considerably longer than the recommended minimum test–retest period sufficient to avoid familiarity effects, a conservative interpretation is that this could have still been a contributing factor at this stage of development. However, the absence of a similar pattern of accelerated growth between the ages of 16 and 17 years makes familiarity effects a less likely explanation.

The general pattern of consistent language development described above remained evident when searching for distinctive subgroups of individuals with differing developmental language trajectories. A microanalytical approach was taken following from our aim to examine in detail any potential differences in growth trajectories

Figure 6. Individual developmental trajectories and average developmental trajectories of PIQ ability in PIQ Subgroups 1 to 6.



within the sample. Thus, seven subgroups were identified. These subgroups did not differ in their developmental trajectories but only in the relative level of language functioning. All seven subgroups developed in a parallel fashion, indicating no distinctive patterns of language growth in any subgroups of this sample of individuals with a history of SLI. It is important to note that the participants in this study had been deemed to require language units given their language difficulties, and that the majority of children in our sample had both expressive and receptive difficulties at age 7 (only 38% manifested difficulties predominantly in only one area; Conti-Ramsden & Botting, 1999a). Stability of language growth may not be so evident in samples with different characteristics—for example, individuals with SLI from epidemiological or community samples. Nonetheless, the findings are consistent with accumulating evidence that, from about age 6 years, children with a history of SLI appear to have stable growth of language skills, at least when measured as core skills in expressive and receptive modalities (Beitchman et al., 1996; Bishop & Edmundson, 1987; Rice et al., 1998, 2006; Silva, Williams, & McGee, 1987). It remains an open, empirical question whether other dimensions of language functioning, such as vocabulary

or pragmatic language skills, also have stable trajectories from childhood to adolescence.

Why do we observe stability in language growth? The results are generally consistent with both maturational and neuroconstructivist explanations. Maturational explanations would suggest that the observed consistency in language growth trajectories of individuals with SLI is likely to be related to a maturational lag in their verbal skills. Once there is language-specific onset of these abilities, growth curves should be stable and relatively invariant. Neuroconstructivist explanations would suggest that small, subtle differences in domain-general mechanisms and/or the parameters of brain development in SLI—for example, small differences in the developmental timing of memory mechanisms for processing and storing auditory information—could result in a language-specific delay in early childhood. Neuroconstructivist approaches do not necessarily predict uniformity of language growth across development but instead suggest that growth analysis can be particularly revealing when we examine concurrently more than one domain of functioning in neurodevelopmental disorders, such as SLI.

The present investigation afforded an evaluation of the relationship between expressive and receptive

Table 4. Cross-tabulation of the language and PIQ subgroups.

Language subgroups	PIQ subgroups						PIQ score		
	1	2	3	4	5	6	Total	Scaled	Standard
1	7 (44%)	7 (44%)	2 (13%)	0 (0%)	0 (0%)	0 (0%)	16	1.07 (0.72)	114.36 (14.15)
2	12 (24%)	17 (34%)	14 (28%)	3 (6%)	3 (6%)	1 (2%)	50	0.51 (0.83)	106.72 (16.95)
3	9 (13%)	22 (32%)	18 (26%)	5 (7%)	2 (3%)	13 (19%)	69	0.14 (0.89)	99.32 (19.37)
4	4 (8%)	7 (14%)	11 (22%)	9 (18%)	4 (8%)	15 (30%)	50	-0.24 (0.90)	92.96 (19.53)
5	0 (0%)	1 (9%)	3 (27%)	1 (9%)	0 (0%)	6 (55%)	11	-0.84 (0.95)	81.93 (23.28)
6	0 (0%)	5 (13%)	8 (21%)	6 (16%)	6 (16%)	13 (34%)	38	-0.56 (0.81)	87.63 (19.12)
7	0 (0%)	2 (25%)	0 (0%)	2 (25%)	1 (13%)	3 (38%)	8	-0.70 (0.86)	82.87 (19.51)
Total	32	61	56	26	16	51	242		
PIQ scaled	1.43 (0.49)	0.63 (0.51)	0.02 (0.46)	-0.52 (0.51)	-0.66 (0.67)	-1.16 (0.64)			
PIQ standard	120.63 (9.70)	108.39 (13.86)	98.21 (13.83)	88.18 (18.61)	82.85 (10.84)	76.83 (18.24)			
Expressive scaled	0.64 (0.91)	0.28 (0.90)	0.09 (0.93)	-0.45 (0.92)	-0.35 (1.05)	-0.45 (0.92)			
Expressive standard	86.16 (14.34)	90.21 (13.59)	78.56 (13.62)	72.60 (10.90)	72.63 (12.60)	72.23 (11.54)			
Receptive scaled	0.80 (0.76)	0.30 (0.98)	0.13 (0.86)	-0.46 (0.92)	-0.41 (0.95)	-0.63 (0.85)			
Receptive standard	96.30 (14.72)	87.19 (14.46)	83.48 (13.55)	76.41 (13.51)	77.07 (11.54)	74.75 (12.06)			

Note. The average PIQ scaled and standard scores are given for each language and PIQ subgroup, respectively. For the PIQ subgroups, the average receptive and expressive scaled and standard scores are also given. Estimates are averages across all time points. Percentages are row percentages, that is, for each subgroup, the proportion of children in the different PIQ subgroups.

language abilities in SLI. Findings suggest that receptive language abilities are at a similar level to or better than expressive language skills. More important, this appears to be a characteristic of SLI and is reflected in the majority of subgroups identified. That is, it appears that in SLI, it is unusual for expressive language abilities to be significantly better than receptive language skills. This unusual pattern did obtain in Subgroup 5 and to a lesser extent in Subgroup 7. We also found in development relative stability in these observed patterns of relationships. Data from the discrepancy trajectories analysis suggest consistent relationships between receptive and expressive language in SLI from childhood to adolescence, even in the case of the less common expressive-better-than-receptive language skills profile (Subgroup 5). The exception was the small Subgroup 7, where receptive scores increased relative to expressive scores across time, although functioning in both modalities was consistently poor in relation to the average for the sample. It would be of interest for future research to examine other aspects of functioning in individuals with such unusual patterns of language functioning in order to ascertain the developmental impact of being able to express more than one can understand.

Growth of Nonverbal Skills in SLI

We also investigated trajectories of nonverbal skills in individuals with SLI by using models that attempted to account for measurement confounds and the use of standard scores for comparisons across time. Using our scaled scores approach with the whole sample, we found an overall stable pattern of growth in nonverbal skills from childhood to adolescence. Thus, when using scaled scores, we do not find the pattern observed in previous research, that is, a general overall deceleration of nonverbal skills for the group as a whole (Botting, 2005; Mawhood et al., 2000; Stothard et al., 1998; Tomblin et al., 1992). However, this general pattern of stable growth was not maintained when investigating distinctive subgroups of individuals with differing developmental trajectories of nonverbal skills. Six subgroups were identified that differed not only in the relative level of nonverbal functioning but also in the shapes of their developmental trajectories.

Recall that all subgroup means for nonverbal abilities were within the normal range at 7 years. This needs to be kept in mind when discussing differences in the level of nonverbal functioning of different subgroups, that is, when we refer to above the mean for the group or below the mean for the group. Subgroups 1, 2, and 3, the three subgroups with higher nonverbal ability (at or above the mean for the group) had relatively flat trajectories. Thus, our findings indicate that nonverbal ability for these individuals was stable, with no evidence

of acceleration or slowing down. This pattern of growth in nonverbal skills was the most common pattern observed, holding for approximately 62% of the sample. It is also of interest to note that in nonverbal ability Subgroups 1, 2, and 3 had higher language skills than the other subgroups.

How about subgroups with lower nonverbal abilities, that is, nonverbal abilities below the mean for the group? For Subgroups 4 and 6, there was clear evidence of slowing down in the growth of nonverbal skills from childhood to adolescence. This developmental pattern of growth was evident in nearly one third of the sample (32%). Consistent with previous research in this area (Botting, 2005; Mawhood et al., 2000; Tomblin et al., 1992), changes in the standard scores from childhood to adolescence revealed that these individuals with a history of SLI who in childhood had nonverbal skills within the normal range did not continue to do so later in development.

It is important to note that these are not deterministic relationships, as variability was observed, in particular the presence of a proportion of individuals with similar characteristics who did not show this slowing-down pattern of growth (Subgroup 5). Subgroup 5 showed evidence of accelerated growth of nonverbal skills. This subgroup had the lowest mean nonverbal score at 7 years in relation to the rest of the group. However, this subgroup was small, comprising less than 7% of the sample. Additional analyses of standard scores suggest that the gains in nonverbal skills from childhood to adolescence were modest.

Maturation accounts of SLI predict little or no relationships between verbal and nonverbal functioning in SLI (Rice, Tomblin, Hoffman, Richman, & Marquis, 2004). We observed that dissociations across different domains of functioning are not necessarily maintained over development. In this sense, our findings are more consistent with a neuroconstructivist approach. This is because this framework predicts co-occurring impairments, which may be more or less evident over development, as SLI is not likely to be the result of domain-specific abnormalities or damage (Thomas & Karmiloff-Smith, 2002). Indeed, we found that one third of individuals with a history of SLI would no longer meet criteria for the disorder in later childhood and adolescence as they exhibit poor nonverbal skills. Our data also fit well with the neuroconstructivist view that atypical development is progressive and the result of interactions at multiple levels and across domains of functioning (Karmiloff-Smith, 1998).

Why did we observe slowing down in nonverbal skills for some individuals with a history of SLI? One possibility is that, as language mediates most aspects of our engagement with the world, much learning depends on being

able to articulate and understand verbal representations. For those who are more severely impaired, the processes are curtailed. Indeed, early language difficulties could impact on children's educational pathways, such that some receive fewer opportunities to practice the skills that are tapped in nonverbal reasoning tasks. A long-term consequence is relatively slower growth in nonverbal abilities. Taken together, the data on the trajectories of verbal and nonverbal skills presented in this study invite further research to examine potential interactive influences between these domains across development in individuals with SLI.

Limitations and Implications

Ideally, empirical questions about developmental growth in SLI would be addressed using the same set of measures over time that reflect similar language and nonverbal constructs or by a study embedded within or collected together with a parallel general population cohort. Our study was not originally designed for investigating trajectories of growth and as such had a number of limitations—for example, measurement changes and attrition. In the Method section, we have detailed these and how we have accounted for them in our analyses. Although this has achieved much in relation to understanding relative change, it provides no additional insight as to progress compared with population norms. In addition, our study focused on a sample of individuals with a history of SLI and does not provide data of a comparison group of typically developing individuals. Thus, our findings speak to similarities and differences within a large sample of individuals with language impairments but are moot on the patterns in other groups.

Notwithstanding these caveats, the present study is able to add to the body of work on the developmental language trajectories of individuals with a history of SLI in three important ways. First, it specifies that complex approaches to subgrouping (taking multiple time points across both expressive and receptive language modalities) yield similar findings to analyses involving a single language modality across time by using a single measure of receptive grammar (Law et al., 2008). In these analyses, similar, parallel growth was observed in individuals with a history of SLI. The overall pattern appears to be consistent. Of importance, our findings show that this is not likely to be an artifact of pooling data across the heterogeneity of SLI but holds even when quite fine distinctions among subgroups are examined.

Second, this study provides evidence that the aforementioned pattern is applicable to the majority of individuals with SLI. Approximately three quarters of individuals were considered to manifest “prototypical” developmental language trajectories of the subgroups identified. These data suggest that from age 7, most

individuals with history of SLI develop language at a stable rate of growth in later childhood and adolescence. What is important to note, then, is that the level of language functioning or severity of impairment identified at age 7 is informative not only because of what it tells us about the child's needs at that point in development but also because of its longer-term implications. The relative level of attainment at 7 years was maintained across development: Those who had poorer language in relation to the rest of the SLI group continued to do so, whereas those with higher language abilities continued to exhibit higher levels of functioning in relation to the rest of the group.

Third, although effective therapists may be able to assist children to maximize their potential and even to achieve beyond the range their trajectory would otherwise follow, it is important to recognize the constraints associated with early language abilities. Clinicians are likely to encounter in their practice some individuals who do not “fit” the pattern of steady developmental trajectories described here. A key implication of this study is that, on the one hand, from at least 7 years of age onward, individuals who make substantial gains via accelerated growth are the exception and not the rule, and a distinction should be drawn between lasting change and good performance on a single test. Exceptions in the pattern of developmental trajectories can occur among those with relatively good language abilities at 7 years of age as well as those with poorer language skills. On the other hand, slowing down of language growth is also unusual and not common in SLI, unlike in the case of individuals with other neurodevelopmental disorders, such as epilepsy (McVitar & Shinnar, 2004). There is also evidence that language regression, that is, language loss, is rarely observed in SLI in early childhood (Pickles et al., 2009).

The present investigation also has implications for the definition, diagnosis, and provision of services of individuals with a history of SLI. The classic definition of SLI is static and specifies the presence of significant language deficits in the context of nonverbal abilities within the normal range. This definition does not capture the developmental progression of SLI and the fact that there are at least two different developmental trajectories of the disorder with different phenotypical characterizations: In one case, we observe stability of growth of nonverbal skills; and in the other, we observe slowing down of nonverbal skills growth over developmental time. Thus, approximately one third of individuals with a history of SLI will appear more generally impaired in late childhood and adolescence. They will no longer meet criteria for SLI diagnosis and thus may be at risk of not being eligible for specialized language services. There is therefore an urgent need to include this type of developmental information as a key element

of the description of SLI and its developmental courses. There is also a need to evaluate nonverbal skill in children with SLI at multiple time points during their development from childhood to adolescence.

Conclusion

Although early childhood has been a major focus of research on SLI, the findings of this study suggest that evidence from childhood to adolescence can also provide insightful information regarding the dynamic, developmental nature of this condition and the complex interrelationships between language impairment and other aspects of development. Future research is needed to examine the relationships between developments in language and other important areas of child and adolescent development, such as social, behavioral, and emotional functioning. Further research is also needed to examine the impact on adult outcomes of a history of consistent language difficulties and, in a notable proportion of individuals, a slowing down in the growth of their nonverbal skills.

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